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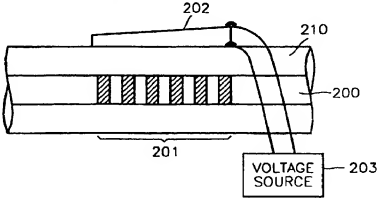
(54) Tunable chirped fiber grating device and method

(57) A tunable chirped grating device an optical fiber having the same spacings between index perturbations, a piezoelectric element bonded to the optical fiber, for changing the perturbation spacings according to an applied voltage, and a voltage source for applying the voltage to the piezoelectric element. Since a predetermined piezoelectric element is bonded to an optical fiber provided with a grating having regular spacings and the perturbation spacings can be differently deformed by applying different electric field to respective perturbation positions by the piezoelectric element, and the chirping rates of the reflected wavelengths waves can be adjusted, a chirped grating device whose manufacturing procedure is simple and which has flexibility can be provided.

FIG. 2



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Description

[0001] The present invention relates to a tunable chirped fiber grating device in which the spacings of perturbations in the index of refraction vary with a strain which is produced by applying a voltage across a predetermined piezoelectric element and a method for forming a chirped fiber grating.

[0002] A chirped grating is designed to have different perturbation spacings or different effective refractive indices depending on positions of the perturbations, and is characterized in that the wavelength of reflected light differs depending on the positions of the perturbations. FIGS. 1A and 1B show side views illustrating an optical fiber in which a chirped grating is formed. Here, a core is represented by reference numeral 100 or 120, a cladding by 110 or 130, and a grating by 101 or 102. The chirped grating 101 in the core 100 according to FIG. 1A has a structure in which the spacings of successive perturbations are different from each other, while the effective refractive indices of the perturbations are the same, and a chirped grating 102 in the core 120 according to FIG. 1B has a structure in which the spacings of successive perturbations are the same, while the effective refractive indices of the perturbations are different from each other.

[0003] However, such chirped gratings are doomed to experience more complicated procedures than those having equal perturbation spacings, and since the chirping rates of the reflected wavelengths according to the positions of the perturbations are fixed to values in fabrication conditions and therefore the gratings can be used for a specific wavelength band, and the gratings cannot be applied flexibly.

[0004] According to a first aspect of the invention there is provided a tunable chirped grating device characterized in that the tunable chirped grating device includes an optical fiber having the same spacings between index perturbations, a piezoelectric element bonded to the optical fiber, for changing the perturbation spacings according to an applied voltage, and a voltage source for applying the voltage to the piezoelectric element.

[0005] It is thus an advantage of the present invention to provide a tunable chirped grating device whose perturbation spacings differ from each other by attaching an element whose length can vary with an applied voltage to an optical fiber including a grating in which spacings between perturbations are are regular and controlling the applied voltage, and a method for forming a chirped fiber grating.

[0006] According to a second aspect of the invention there is provided a method for forming a chirped fiber grating characterized in that the method includes the steps of (a) forming a grating having regularly spaced perturbations in the optical fiber, and (b) causing the perturbation spacings of the optical fiber grating to differ from each other by applying different tensions to the optical fiber grating according to the positions of the perturbations.

[0007] There now follows a description of preferred embodiments of the invention, by way of non-limiting example, with reference to the attached drawings in which:

FIGS. 1A and 1B are side views illustrating a prior art optical chirped grating; and

FIG. 2 is a side view illustrating the structure of a tunable chirped grating device according to the present invention.

[0008] FIG. 2 shows a side view illustrating the structure of a tunable chirped grating device according to the present invention. The tunable chirped grating device shown in FIG. 2 includes an optical fiber in which a grating 201 having perturbations which have the same refractive index perturbations and regularly spaced therebetween in a core 200 formed inside a cladding 210, a piezoelectric element 202 attached to the optical fiber, and a voltage source 203 for supplying a voltage to the piezoelectric element 202.

[0009] A method for forming a chirped grating using the above described structure is as follows. That is, the grating 201 having regularly spaced perturbations is formed in the optical fiber core 200, and the spacings of perturbations are caused to differ from each other by applying different tensions to the optical fiber grating 201 according to the positions of the perturbations. The tensions are created by the piezoelectric element 202 and the voltage source 203.

[0010] The grating 201 satisfies the following Bragg condition in the optical fiber core 200.

$$\lambda_i = 2 \cdot n_{eff} \cdot d_i$$

where λ_i is the wavelength of an incident wave, n_{eff} is the effective index of refraction, and d_i is the spacing between perturbations.

[0011] The material of the piezoelectric element 202 attached on the outside of the grating 201 is a material which can be deformed according to the voltage applied by the voltage source 203, and $Pb(Zr_xTi_{1-x})O_3$, $0.4 \leq x \leq 0.6$ (PZT or Lead Zirconate Titanate) is preferably appropriate for the material. Epoxy may be used as the adhesive. The piezoelectric element 202 made of a material such as PZT deforms in a direction perpendicular to the applied electrical field. The shape of the piezoelectric element 202 is preferably wedge-shaped in order for deformations at each position to occur with different degrees from each other according to the applied voltage. That is, though the applied voltage is constant, as a portion of the piezoelectric element 202 is thicker, the electrical field becomes relatively weaker than a thinner portion. As a result, the thinner portion deforms to a smaller extent than the thicker portion.

[0012] The perturbation spacings of the grating 201

bonded to the piezoelectric element 202 having the above-described characteristics vary with the deformation of the piezoelectric element 202. Consequently, a chirped grating device having different spacings between perturbations can be formed. Further, when the voltage applied by the voltage source 203 is adjusted, the chirping rates of the reflected wavelengths can be adjusted.

[0013] According to the present invention, since a predetermined piezoelectric element is bonded to an optical fiber provided with a grating having regular perturbation spacings and the perturbation spacings can be differently deformed by applying different electrical fields to respective perturbation positions by the piezoelectric element, and the chirping rates of the reflected wavelengths can be adjusted, a chirped grating device whose manufacturing procedure is simple and which has flexibility can be provided.

Claims

1. A tunable chirped grating device,
   characterized in that the tunable chirped grating device comprises:

   an optical fiber having the same spacings between index perturbations;
   a piezoelectric element bonded to the optical fiber, for changing the perturbation spacings according to an applied voltage; and
   a voltage source for applying the voltage to the piezoelectric element.

2. The tunable chirped grating device as claimed in claim 1, wherein the material of the piezoelectric element is $Pb(Zr_xTi_{1-x})O_3$.

3. The tunable chirped grating device as claimed in claim 1 or claim 2, wherein the shape of the piezoelectric element is wedge-shaped so that deformations at each position may occur with different degrees according to the applied voltage.

4. A method for forming a chirped grating,
   characterized in that the method includes the steps of:

   (a) forming a grating having regularly spaced perturbations in the optical fiber; and
   (b) causing the perturbation spacings of the optical fiber grating to differ from each other by applying different tensions to the optical fiber grating according to the positions of the perturbations.

5. The method as claimed in claim 4, wherein the method for applying the tensions comprising the steps of:

   bonding a wedge-shaped piezoelectric element to the optical fiber grating; and
   causing the optical fiber grating to be differently deformed according to the positions of the perturbations as the piezoelectric element are deformed with relatively different degrees according to the positions thereof upon applying a voltage to the piezoelectric element.

FIG. 1A (PRIOR ART)

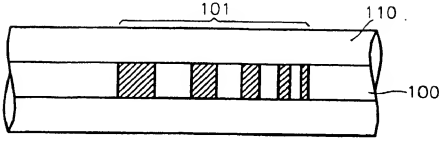


FIG. 1B (PRIOR ART)

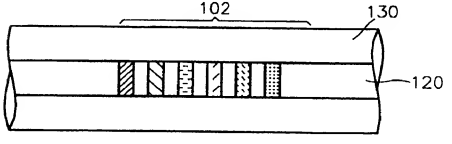
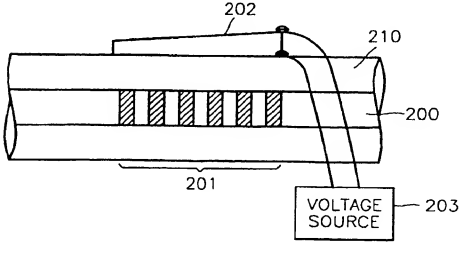


FIG. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 98 31 0765

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 5 694 501 A (ALAVIE TINO A ET AL) 2 December 1997 * abstract; figures 5A,5B * * column 3, line 27 - column 5, line 3 * ---	1,2,4	G02F1/01
X	OHN M M ET AL: "Dispersion variable fibre Bragg grating using a piezoelectric stack" ELECTRONICS LETTERS, 10 OCT. 1996, IEE, UK, vol. 32, no. 21, pages 2000-2001, XP000683539 ISSN 0013-5194 * the whole document * ---	1,2,4	
A	CRUZ J L ET AL: "Fibre Bragg gratings tuned and chirped using magnetic fields" ELECTRONICS LETTERS, 30 JAN. 1997, IEE, UK, vol. 33, no. 3, pages 235-236, XP000725938 ISSN 0013-5194 * the whole document * ---	1,4	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G02F
P,X	PACHECO M ET AL: "Chirping optical fibre Bragg gratings using tapered-thickness piezoelectric ceramic" ELECTRONICS LETTERS, 26 NOV. 1998, IEE, UK, vol. 34, no. 24, pages 2348-2350, XP002099851 ISSN 0013-5194 * the whole document * -----	1-5	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 April 1999	Iasevoli, R

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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16-04-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5694501 A	02-12-1997	CA 2134958 A	03-05-1996

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82